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RADIATION MEMBER AN D APPARATUS, CAGE AND COMPUTER SUPPORT INCLUDING THE RADIATION MEMBER

Cross Reference to Related Application

[0001] This application is a **national stage** of PCT/JP2004/011557 filed August 11, 2004 and based upon PCT/JP03/10213 filed August 11, 2003 under the International Convention.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] This invention relates to a heat-radiating member having excellent heat-radiation performance, a device that uses that heat-radiating member, a casing, a computer-support stand, and a method for manufacturing the heat-radiating member.

Description of the Related Art

[0003] Conventionally, in devices that generate heat such as heat exchangers, as in an internal-combustion engine or refrigerator, or electronic devices such as the CPU of a computer, the heat-radiation unit that manages that heat radiation, for example, a heat-radiation fin, muffler of an internal-combustion engine, various kinds of electric motors, heat sinks or the like, have been treated with a black coating to improve the heat-radiation effect.

[0004] However, in performing just a black coating, further improvement of the heat-radiation effect can not be expected, so in various devices that generate heat such as mentioned above, the construction of the heat-radiation unit is specially designed (for example, construction that promotes heat convection, etc.) in order to improve heat-radiation effect.

[0005] An example of this is simple construction that comprises a circuit component that is equipped with a plurality of busbars of an electric power circuit, and a heat-radiating member having a busbar-bonding surface that is coated with an insulation layer; and by arranging the plurality of busbars on this busbar-bonding surface such that each busbar is

directly bonded to the busbar-bonding surface, the busbars are efficiently cooled (see Japanese patent publication 2003-164040).

[0006] Also, as another example, is an electrical-wiring box in which an insulation board that is supported and located in a space between a current-distribution circuit board and printed-circuit board is eliminated, and the heat-radiation performance is improved by the existence of the space (for example, see Japanese patent publication 2003-87938).

[0007] Examples of employing features in the construction for improving the heat-radiation effect where given above, however, in order to further improve the heat-radiation effect, it is necessary to reconsider the member itself.

[0008] However, it is extremely difficult to improve the physical property of thermal conductivity by improving the material itself.

[0009] Therefore, as described above, a base material such as copper or aluminum having high thermal conductivity is treated with a black coating that has a heat-radiating and heat-adsorption effect, however, the object of this invention is to provide a heat-radiating member, device that uses that heat-radiating member, casing, computer-support stand and method for manufacturing the heat-radiating member that make it possible to expect more heat-radiation effect than from a heat-radiating member that is treated with a black coating.

[Patent Document 1]

Japanese Patent Publication 2003-164040

[Patent Document 2]

Japanese Patent Publication 2003-87938

SUMMARY OF THE INVENTION

[0010] In order to solve the aforementioned problems, the inventor of this invention applied various sample materials to a base material and tested the heat-radiation state, and found that tourmaline had very remarkable effect (discovered specified attributes), then as a result of dedicated research, found from among various kind of tourmaline existing in nature such as dravite tourmaline, schorl tourmaline, mixed tourmaline, lithia tourmaline, etc., a

tourmaline that provided an excellent heat-radiation effect, and further found, even for that tourmaline which had excellent heat-radiation effect, the existence of a grain diameter and a density (amount of coating) per unit area that provided outstanding heat-radiation effect. In this way, the inventors focused on a specific tourmaline and used that tourmaline powder (exclusively used those properties and attributes) to invent a heat-radiating member capable of solving the aforementioned problem.

[0011] In other words, the heat-radiating member comprises a tourmaline layer that is formed by mixing schorl tourmaline powder having a grain diameter of 3 to 7 μm with a liquid-form fixing agent to form a coating agent, then applying that coating agent to the surface of a base material, which is made from a metal such as copper, aluminum or the like having excellent heat conductivity, until the density of the schorl tourmaline powder is 0.25 to 0.05 grams per cm^2, and allowing it to harden.

[0012] The heat-radiating member is formed by mixing schorl tourmaline powder having a grain diameter of 3 to 7 μm with a base material made from aluminum.

[0013] The heat-radiating member is formed by mixing schorl tourmaline powder having a grain diameter of 3 to 7 μm with a base material made from plastic.

[0014] The device such as heat exchanger or various kinds of appliances wherein a heat-generating section that generates heat, and/or a heat-radiating section that radiates heat is constructed using the heat-radiating member.

[0015] The device that is constructed using the heat-radiating member and is a cooling device, and said heat-radiating member is used in the heat-exchange system of said cooling device.

[0016] The case comprising an electric device such as a computer or hard disk drive and that is constructed using the heat-radiating member.

[0017] The computer support stand on which a notebook computer is placed and that is formed into an L shape as seen from the side and on which the heat-radiating member is placed.

[0018] The method for manufacturing a heat-radiating member comprising:

a coating-agent-creation step of creating a coating agent by mixing schorl tourmaline powder having a grain diameter of 3 to 7 μm with a fixing agent; and

a coating step of applying the coating agent to the surface of a base material, which is made of a metal such as copper, aluminum or the like having excellent heat conduction, so that the density of the schorl tourmaline powder becomes 0.025 to 0.05 grams per cm^2.

[0019] The method for manufacturing a heat-radiating member wherein molten aluminum is mixed with schorl tourmaline powder, then molded and hardened into a desired shape.

[0020] The method for manufacturing a heat-radiating member wherein liquid plastic is mixed with schorl tourmaline powder, then molded and hardened into a desired shape.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] In the drawings:

Fig. 1 is a sectional view of the heat-radiating member of a first embodiment of the invention.

Fig. 2 is a drawing for explaining the testing of the heat-radiation effect.

Fig. 3 is a drawing showing the case in which the heat-radiating member is applied to a refrigerator.

Fig. 4 is a drawing showing the case in which the heat-radiating member is applied to a desktop computer.

Fig. 5 is a drawing showing the case in which the heat-radiating member is applied to a notebook computer.

Fig. 6 is a drawing showing the case in which the heat-radiating member is applied to an electric motor.

Fig. 7 is a side view of the support stand for a notebook computer.

Fig. 8 is a top view showing the grain-diameter selection test.

Fig. 9 is a front view showing the grain-diameter selection test.

DETAILED DESCRIPTION OF THE INVENTION

[0022] In order to explain the present invention in more detail, the invention will be explained with reference to the supplied drawings.

[0023] In the drawings, reference number 1 indicates the heat-radiating member, reference number 11 indicates the base material, and reference number 12 indicates the tourmaline layer.

(Embodiment 1)

[0024] As shown in Fig. 1, the heat-radiating member 1 of this embodiment comprises: a base material 11 made from a thin copper plate (0.8 mm plate thickness) having high heat conductivity; and a tourmaline layer 12, having schorl tourmaline powder as the main component, coated on the top surface of that base material 11.

[0025] This tourmaline layer 12 is formed by mixing schorl tourmaline powder, having a grain size of 6 μm, with a fixing agent made from an acrylic volatile synthetic resin coating material at a weight ratio of 1:1 (coating formation step) to form a coating, and then coating the base material 11 with multiple coats of that coating material until the density of the tourmaline powder becomes 0.025 to 0.05 grams per cm^2 (coating step), and finally letting the coating harden.

[0026] Typical tourmaline such as dravite tourmaline, schorl tourmaline, mixed tourmaline, or lithia tourmaline were used to perform preliminary heating tests, and a blackened schorl tourmaline having the best heat-radiation effect was employed.

[0027] More specifically, it is well known that tourmaline gives off ions, or generates electricity, however, based on the law of conservation of energy, in order for tourmaline to give off ions or generate electricity, it is necessary for there to be some kind of input energy, and guessing from the effect of this invention, it is thought that heat energy changes to ions or electricity.

[0028] Therefore, it is estimated that schorl tourmaline having high voltage between electrodes will have the best heat-radiation effect.

[0029] The reason that the weight ratio of fixing agent to schorl tourmaline powder is made to be 1:1 is that it has been confirmed through testing that when the fixing agent dries and hardens there is a good balance in order to maintain the dense state of the schorl tourmaline powder; and when the amount of fixing agent is less than the amount of schorl tourmaline powder it becomes easy for the tourmaline to peal from the base material, and when the amount of fixing agent is greater than the amount of schorl tourmaline powder, multiple coats are required in order to obtain the desired schorl tourmaline density, so workability becomes poor. Moreover, when 20 g of liquid-state acrylic volatile synthetic resin coating material dries it becomes 4 g.

[0030] Furthermore, a grain-diameter-selection test, coating-amount-selection test, and fixing-agent-selection test are further performed on the aforementioned schorl tourmaline, which had the best heat-radiation effect, and the tourmaline layer 12 is constructed based on the especially good data obtained from those test results. Each of the selection tests will be explained in more detail later.

[0031] Also, the liquid in which this schorl tourmaline powder is mixed is not limited to the acrylic volatile synthetic resin coating material mentioned above, and it is also possible to use a well known heat-resistant coating material such as a water-based emulsion type coating material, or a two-component epoxy coating material, or in other words, any liquid material could be used as long as it will harden and not easily peal from the base material 11 (maintained in a coated state over a long period of time).

[0032] Also, schorl tourmaline powder having a grain size of 3 to 7 μm can be mixed with the molten aluminum or plastic base material and allowed to harden in a desired shape.

[0033] Tourmaline (not limited to schorl tourmaline) is broken down by applying heat of 900 °C or more, so aluminum, which has excellent heat conductivity, and a melting point of 660 °C is the most suitable material to use in the case where the base material itself contains schorl tourmaline powder as described above.

[0034] Moreover, in the case where schorl tourmaline powder is contained in a plastic base material itself, the pellets and schorl tourmaline powder are mixed at a weight ratio of 10%, and it is possible to manufacture a heat-radiating member having a desired shape using conventional molding means such as typical injection molding.

[0035] Next, heat-radiation testing using the heat-radiating member 1 of the embodiment constructed as described above will be explained.

[0036] During testing, as objects of comparison, a 0.8 mm thick copper plate base material 11, of which only the top surface was coated black (hereafter referred to as comparison sample A), and that base material 11 as is (hereafter referred to as comparison sample B) were used, and the state of heat radiation was compared with that of the heat-radiating member of this embodiment.

[0037] In the outline of the testing as shown in Fig. 2, temperature sensors C were attached to part of the surfaces of the tourmaline layer 12 and the side opposite from the black coated surface (for just comparison sample B there is no direction of the application surface of the temperature sensor), and the heat-radiating member 1 and either comparison sample A or comparison sample B are selected, and the two are simultaneously placed on the top of a home-use heating appliance (hot plate) D. When doing this, the tourmaline layer 12 and the black coating are placed so that they are on the top, and the heat-radiating member 1 and comparison sample A or comparison sample B are place on the home-use heating appliance D so that the temperature sensors C are away from the heating appliance so that they are not affected by the heat of the home-use heating appliance D itself.

[0038] Also, by supplying electric power to the home-use heating appliance D, the temperature of the members placed on the top of the home-use heating appliance D rises to a suitable temperature, and by measuring the rise in temperature at that time away from the home-use heating appliance D, it is possible to know the state of heat radiating from the top surface. In other words, since the material of the base material 11 itself, the placement conditions, and heating conditions are the same, it is possible to gain an understanding of the heat-radiation effect of each member in the case in which there is a black-coated layer formed on the surface of the base material 11, when there is a tourmaline layer 12 and when there is no formation layer.

[0039] Under these conditions, first the heat radiation test results for heat-radiating member 1, comparison sample A and comparison sample B are explained.

[0040] First, when measuring the temperature of heat-radiating member 1 and comparison sample B under the same conditions, the temperature of heat-radiating member 1 was 43.5 °C, while the temperature of comparison sample B was 51.7 °C. That temperature difference was 8.2 °C, so it was found that the heat-radiating member 1 had better heat-radiation effect.

[0041] Next, when measuring the temperature of heat-radiating member 1 and comparison sample A under the same conditions, the temperature of heat-radiating member 1 was 54.5 °C, while the temperature of comparison sample A was 57.8 °C. The temperature difference was 3.3 °C, so it was found that the heat-radiating member 1 had better heat-radiation effect.

[0042] From the above, it was found that the heat-radiating member 1 of this embodiment had better heat-radiation effect than both comparison sample A and comparison sample B. Also, the heat-radiating member 1 of this embodiment is constructed such that it has a thin plate shape, so the cutting process and bending process are simple, and processing can be performed so that it can be applied to various kinds of heat-radiating sections.

[0043] Next, the grain-diameter-selection test, coating-amount-selection test, and fixing-agent-selection test that were performed in order to select the tourmaline layer, which uses schorl tourmaline, for the heat-radiating member of the embodiment described above, will be explained in detail.

1. Grain-diameter-selection test

[0044] The heat-radiation effect according to grain diameter of schorl tourmaline will be explained.

[0045] Heat-radiating member specimens M2 were prepared by mixing schorl tourmaline powder having grain diameters 1.2 μm, 3μm, 325 mesh, and 6μm with a fixing agent made from an acrylic volatile synthetic resin coating material at a weight ratio of 1:1 (30g : 30g) to create four sample coating materials, and then applying each coating material onto one surface of a copper plate having dimensions 300 mm x 200 mm x 0.8 mm (vertical width x horizontal width x thickness) until the density of the schorl tourmaline was 0.05 grams per cm^2 (applied on one surface), to make four heat-radiating member specimens M2.

[0046] Also, as shown in Fig. 8 and Fig. 9, a copper plate M1 having dimensions 300 mm x 200 mm x 0.8 mm (vertical width x horizontal width x thickness) was placed on a heating appliance having a thermostat, and the heat-radiating member specimen M2 was placed on top of the copper plate M1 so that the bottom edges were lined up, and so that the tourmaline layer was on the top.

[0047] Moreover, temperature sensors S1 that were connected to a temperature-measurement device S2 were attached to a location 10 mm inward from the center of the right side of the copper plate M1, and at a location 10 mm inward from the center of the top side of the heat-radiating member M2 (tourmaline layer side).

[0048] Also, the temperature setting of the electrical heating appliance D1 was set to 50 °C, and after a pre-heating time of approximately one hour had elapsed, the temperature of the copper plate M1 and the heat-radiating member specimen M2 was measured every 15 seconds (four electrical heating appliances were prepared, and the temperature of the four copper plates and heat-radiating member specimens M2 was measured at the same time).

[0049] The test results that were obtained under the above conditions are shown in the tables below. The very bottom section on the right side of each table shows the average temperature of the heat-radiating member specimen, the average temperature of the copper plate, and the average temperature difference, which is calculated by subtracting the average temperature of the heat-radiating member specimen from the average temperature of the copper plate.

[Table 1]

Test results for schorl tourmaline having a grain diameter of 1.2 μm

t	1.2um 30g	Copper plate temperature	Room Temperature	t	1.2um 30g	Copper plate temperature	Room Temperature
	44.1	47.4	26	6	43.8	46.6	26
	44.1	47.7	26		43.8	46.8	26
	44.2	47.6	26		43.9	47	26
	44.3	47.6	26		43.9	47.2	26
1	44.3	47.5	26	7	44	47.3	26
	44.5	47.8	26		44.1	47.2	26
	44.5	47.7	26		44.1	47.1	26
	44.5	47.4	26		44.2	47.5	26
2	44.4	47.7	26	8	44.3	47.1	26
	44.4	47.8	26		44.3	47.1	26
	44.4	47.2	26		44.3	47.2	26
	44.3	47.1	26		44.3	46.9	26
3	44.3	47.1	26.1	9	44.3	46.9	26
	44.3	46.6	26		44.2	46.9	26
	44.2	46.6	26		44.1	46.7	26
	44	46.8	26		44.1	46.5	26
4	43.8	46.4	26	10	44	46.3	26
	43.6	46.6	26				
	43.5	46.5	26				
	43.6	46.6	26				
5	43.6	46.5	26		44.09	47.03	2.95
	43.6	46.6	26				
	43.7	46.6	26				
	43.7	46.7	26				

[Table 2]

Test results for schorl tourmaline having a grain diameter of 3 µm

t	3um 30g	Copper plate temperature	Room Temperature	t	3um 30g	Copper plate temperature	Room Temperature
	45	49.7	25.6	6	45.1	50.4	25.7
	44.9	49.6	25.7		45.2	50.4	25.7
	45	49.7	25.7		45.3	50.3	25.7
	45.1	49.8	25.7		45.4	50.2	25.7
1	45.1	49.7	25.7	7	45.4	50.1	25.7
	45.2	49.5	25.7		45.4	50.1	25.7
	45.2	49.3	25.7		45.5	50	25.7
	45.2	49.4	25.7		45.6	50	25.7
2	45.2	49.4	25.7	8	45.6	49.8	25.7
	45.2	49.3	25.7		45.5	49.8	25.7
	45.1	49.2	25.7		45.5	49.8	25.7
	45.1	49.1	25.7		45.3	49.8	25.7
3	45.1	49	25.7	9	45.2	49.8	25.7
	45	48.9	25.7		45.1	49.5	25.7
	44.9	48.9	25.7		45	49.5	25.7
	44.9	48.9	25.7		44.9	49.5	25.7
4	44.9	48.9	25.7	10	44.9	49.2	
	44.8	49	25.7				
	44.8	49.1	25.7				
	44.9	49.4	25.7				
5	44.9	49.7	25.7		45.13	49.61	4.48
	44.9	50	25.7				
	45	50.1	25.7				
	45.1	50.1	25.7				

[Table 3]

Test results for schorl tourmaline having a grain diameter of 6 μm

t	6um 30g	Copper plate temperature	Room Temperature
	43.5	48.2	26.1
	43.4	48.2	26
	43.5	48.3	26
	43.5	48.7	26
1	43.4	48.7	26
	43.5	49.1	26
	43.7	49.2	26
	43.7	49.2	26
2	43.7	49.1	26
	43.8	49	26
	43.8	49.1	26
	43.7	49	26
3	43.6	49.3	26
	43.7	48.9	26
	43.7	48.8	26
	43.7	48.7	26
4	43.6	48.6	26
	43.6	48.6	26
	43.3	48.2	26
	43.3	47.9	26
5	43.3	47.7	26
	43.3	47.9	26
	43.4	48.1	26
	43.4	47.8	26
6	43.4	47.9	26
	43.3	48.4	26
	43.2	48.6	26
	43.3	48.7	26
7	43.3	48.9	26
	43.5	49.2	26
	43.6	49	26
	43.6	49.1	26
8	43.6	49.4	26
	43.6	49.6	26
	43.7	49.4	26
	43.9	49.4	26
9	43.8	49.6	26
	43.8	49.5	26
	43.8	49.4	26
	43.8	49.1	26
10	43.8	49.4	26
	43.56	48.80	5.24

[Table 4]

Test results for schorl tourmaline having a grain diameter of 325 mesh

t	325 mesh	Copper plate temperature	Room Temperature	t	325 mesh	Copper plate temperature	Room Temperature
	45.2	49	26.2	6	45.7	49.8	26.4
	45.2	48.7	26.2		45.7	49.8	26.4
	45.1	48.8	26.2		45.6	49.8	26.4
	45	48.6	26.2		45.4	49.6	26.4
1	45	48.8	26.2	7	45.2	49.4	26.4
	44.9	49.1	26.3		45.1	49.3	26.4
	45	49.2	26.3		45.7	49.4	26.4
	45.1	49.5	26.3		45	49.3	26.4
2	45.1	49.6	26.3	8	44.9	49.4	26.4
	45.1	49.8	26.4		45	49.6	26.4
	45.2	50	26.4		45.1	49.8	26.3
	45.3	50.3	26.4		45.2	49.9	26.3
3	45.3	50.3	26.4	9	45.2	49.8	26.3
	45.3	50.4	26.4		45.3	49.7	26.3
	45.3	50.4	26.4		45.3	49.7	26.3
	45.4	50.6	26.4		45.4	49.9	26.3
4	45.4	50.5	26.4	10	45.4	50	26.3
	45.6	50.5	26.4				
	45.7	50.2	26.4				
	45.8	50.2	26.4				
5	45.8	50	26.4		45.32	49.71	4.39
	45.8	49.9	26.3				
	45.8	49.9	26.4				
	45.7	49.8	26.4				

[0050] From the above it can be seen that the test results obtained showed that a heat-radiating member specimen having schorl tourmaline with a grain diameter of 6 μm had the highest average temperature difference, 5.24 °C, after 10 minutes, followed by 4.48 °C for a grain diameter of 3 μm, 4.39 °C for a grain diameter of 325 mesh, and 2.95 °C for a grain diameter of 1.2μm. From this it is found that the obtained heat-radiation effect peaked when the grain diameter of the schorl tourmaline was 6 μm and began to stand out from a grain diameter of about 3 μm, and when the grain diameter was larger than 6 μm (325 mesh), a small decrease in the heat-radiation effect was seen. Therefore, taking into consideration that it is desired that there be a sense of uniformity of the material (coating strength), and that the surface roughness (small bumps are formed, depending on the schorl tourmaline, when

the liquid fixing agent dries) be decreased as much as possible, schorl tourmaline having a grain diameter of 3 to 7 μm is preferred. Particularly, schorl tourmaline having a grain diameter of 6μm, for which the heat-radiation effect was greatest and for which surface roughness posed no practical problem, is most preferred.

2. Coating Amount Selection Test

[0051] Next, the heat-radiation effect according to the amount of schorl tourmaline coating will be explained.

[0052] Heat-radiating member specimens were prepared by mixing schorl tourmaline powder, having a grain diameter of 6 μm, with a fixing agent, which was made from an acrylic volatile synthetic resin coating material, at a weight ratio of 1:1 (9 g : 9 g, 15 g : 15 g, 30 g : 30 g, 60 g : 60 g) to create four samples of coating material, then applying the coating material to one surface of a copper plate (only one side) having dimensions 300 mm x 200 mm x 0.8 mm (vertical width x horizontal width x thickness), to obtain four heat-radiating member specimens having different densities. In other words, the densities were 0.015 g, 0.025 g, 0.05 g and 0.1 g per 1 cm^2.

[0053] As in the case of the grain-diameter-selection test, copper plates, having dimensions 300 mm x 200 mm x 0.8 mm (vertical width x horizontal width x thickness), were placed on electrical heating appliances with a thermostat, and the heat-radiating member specimens were placed on top of the copper plates so that the bottom edges were lined up, and so that the tourmaline layer was on top.

[0054] Moreover, temperature sensors that were connected to a temperature-measurement device were attached to a location 10 mm inward from the center of the right side of the copper plate, and at a location 10 mm inward from the center of the top side of the heat-radiating member (tourmaline layer side)(see Fig. 8 and Fig. 9).

[0055] Also, the temperature setting of the electrical heating appliances was set to 50 °C, and after a pre-heating time of approximately one hour had elapsed, the temperature of the copper plate and the heat-radiating member specimen was measured every 15 seconds (four electrical heating appliances were prepared, and the temperature of the four copper plates and heat-radiating member specimens was measured at the same time).

[0056] The test results that were obtained under the above conditions are shown in the tables below. The very bottom section on the right side of each table shows the average temperature of the heat-radiating member specimen, the average temperature of the copper plate, and the average temperature difference, which is calculated by subtracting the average temperature of the heat-radiating member specimen from the average temperature of the copper plate.

[Table 5]

Test results for a density of 0.015g per cm ^{2}

t	6um 9g	Copper plate temperature	Room Temperature	t	6um 9g	Copper plate temperature	Room Temperature
	45.1	48.6	26.2	6	44.8	49.1	26.3
	45.1	48.3	26.2		45.1	49.1	26.3
	45.1	48	26.2		45.5	49.1	26.3
	45	48.3	26.2		45.5	49.1	26.3
1	44.9	48.3	26.2	7	45.5	49	26.3
	45	48.2	26.3		45.6	49.2	26.3
	45.1	47.9	26.3		45.6	48.7	26.3
	45.2	47.8	26.3		45.7	48.5	26.3
2	45.1	47.6	26.3	8	45.6	48.4	26.3
	44.8	47.6	26.3		45.4	48.5	26.3
	44.8	47.6	26.3		45.5	48.5	26.3
	44.7	47.5	26.3		45.5	48.1	26.3
3	44.5	47.2	26.3	9	45.3	47.8	26.3
	45	48.4	26.3		45	47.8	26.3
	44.3	47.2	26.3		45	47.6	26.3
	44.1	47.4	26.3		44.9	47.5	26.3
4	44.2	47.7	26.3	10	44.9	47.6	26.3
	44.3	47.9	26.3				
	44.5	47.8	26.3				
	44.8	48.1	26.3				
5	44.7	48.3	26.3		45.00	48.18	3.18
	44.8	48.5	26.3				
	44.8	48.6	26.3				
	44.8	48.9	26.3				

[Table 6]

Test results for a density of 0.025g per cm²

t	6um 15g	Copper plate temperature	Room Temperature
	45.2	48	26.2
	45.3	48	26.2
	45.3	48.1	26.3
	45.3	48.2	26.3
1	45.3	48.5	26.3
	45.1	48.4	26.3
	45	48.5	26.3
	45	48.6	26.3
2	45	48.3	26.3
	45.1	48.4	26.3
	45.1	48.3	26.3
	45.2	48.3	26.3
3	45.2	48.4	26.3
	45.2	48.4	26.3
	45.1	48.3	26.5
	45.1	48	26.5
4	44.8	47.8	26.5
	44.7	47.5	26.5
	44.6	47.5	26.5
	44.6	47.4	26.5
5	44.5	47.5	26.5
	44.4	47.6	26.5
	44.1	47.9	26.5
	44.1	48.1	26.5

t	6um 15g	Copper plate temperature	Room Temperature
6	44.3	48.1	26.5
	44.5	47.8	26.5
	44.8	48.3	26.5
	45	48.5	26.5
7	44.9	48.9	26.5
	45.2	48.6	26.5
	45.1	48.5	26.5
	45	48.8	26.5
8	45	48.7	26.5
	45.2	48.7	26.5
	45.1	48.6	26.5
	45	48.6	26.5
9	45.1	48.6	26.5
	45.2	48.3	26.5
	44.9	48.4	26.5
	44.8	48.2	26.5
10	44.8	48	26.5
	44.93	48.23415	3.30

[Table 7]

Test results for a density of 0.05g per cm 2

t	6um 30g	Copper plate temperature	Room Temperature
	45.2	49	26.2
	45.2	48.7	26.2
	45.1	48.8	26.2
	45	48.6	26.2
1	45	48.8	26.2
	44.9	49.1	26.3
	45	49.2	26.3
	45.1	49.5	26.3
2	45.1	49.6	26.3
	45.1	49.8	26.4
	45.2	50	26.4
	45.3	50.3	26.4
3	45.3	50.3	26.4
	45.3	50.4	26.4
	45.3	50.4	26.4
	45.4	50.6	26.4
4	45.4	50.5	26.4
	45.6	50.5	26.4
	45.7	50.2	26.4
	45.8	50.2	26.4
5	45.8	50	26.4
	45.8	49.9	26.3
	45.8	49.9	26.4
	45.7	49.8	26.4

t	6um 30g	Copper plate temperature	Room Temperature
6	45.7	49.8	26.4
	45.7	49.8	26.4
	45.6	49.8	26.4
	45.4	49.6	26.4
7	45.2	49.4	26.4
	45.1	49.3	26.4
	45.7	49.4	26.4
	45	49.3	26.4
8	44.9	49.4	26.4
	45	49.6	26.4
	45.1	49.8	26.3
	45.2	49.9	26.3
9	45.2	49.8	26.3
	45.3	49.7	26.3
	45.3	49.7	26.3
	45.4	49.9	26.3
10	45.4	50	26.3
	45.32	49.71	**4.39**

[Table 8]

Test results for a density of 0.1g per cm²

t	6um60g	Copper plate temperature	Room Temperature	t	6um60g	Copper plate temperature	Room Temperature
	45.2	48	26	6	46.2	49.1	26.2
	45.3	48.2	26		46.4	49.1	26.2
	45.2	48.5	26		46.1	49.5	26.2
	45.4	48.6	26		46.2	49.6	26.2
1	45.5	48.8	26	7	46.4	50	26.2
	45.4	48.9	26		46.4	50	26.2
	45.5	49	26.1		46.5	49.9	26.2
	45.5	49.1	26.1		46.5	50.1	26.2
2	45.6	49.2	26.1	8	46.4	50.2	26.2
	45.6	49.4	26.1		46.4	50.3	26.2
	46	49.4	26.1		46.5	50.2	26.2
	45.8	49.3	26.1		46.6	49.9	26.2
3	45.9	49.3	26.1	9	46.6	50	26.2
	45.9	48.8	26.1		46.7	49.9	26.2
	45.5	48.8	26.1		46.7	49.9	26.3
	45.5	48.6	26.1		46.6	50	26.2
4	45.6	48.2	26.1	10	46.9	49.7	
	45.6	48.4	26.2				
	45.7	48.6	26.2				
	46	48.6	26.2				
5	46	48.5	26.2		46.00	49.20	**3.20**
	45.9	48.4	26.2				
	45.9	48.5	26.2				
	46.2	48.7	26.2				

[0057] From the above, it can be see that the heat-radiation effect was the greatest for schorl tourmaline having a density of 0.05 g per cm^2 (temperature difference of 4.39 °C), followed by a density of 0.025 g per cm^2 (temperature difference of 3.3 °C), density of 0.1 g per cm^2 (temperature difference of 3.20 °C) and a density of 0.015 g per cm^2 (temperature difference of 3.18 °C). Therefore, it was found that a schorl tourmaline density between 0.05 to 0.025 g per cm^2 was economical and had high heat radiation.

3. Fixing Agent Selection Test

[0058] Next, the heat-radiation effect according the fixing agent will be explained.

[0059] Heat-radiating member specimens were prepared by mixing schorl tourmaline powder, having a grain diameter of 6 μm, with three kinds of fixing agents, acrylic volatile synthetic resin coating material, water-based emulsion type coating material, and two-component epoxy type coating material, at a weight ratio of 1:1 (30 g:30 g) to create three samples of coating material, then applying the coating material to one surface (completely covering the one surface) of a copper plate having dimensions 300 mm x 200 mm x 0.8 mm (vertical width x horizontal width x thickness) so that the density of schorl tourmaline became 0.05 g per cm^2, to obtain three heat-radiating member specimens.

[0060] Also, as in the grain-diameter-selection test, copper plate, having dimensions 200 mm x 300 mm x 0.8 mm (vertical width x horizontal width x thickness), was placed on an electrical heating appliance with a thermostat, and the heat-radiating member specimen was placed on top of the copper plate so that the bottom edges lined up and so that the tourmaline layer was on the top (see Fig. 8 and Fig. 9).

[0061] Moreover, temperature sensors that were connected to a temperature-measurement device were attached to a location 10 mm inward from the center of the right side of the copper plate, and at a location 10 mm inward from the center of the top side of the heat-radiating member (tourmaline layer side).

[0062] Also, the temperature setting of the electrical heating appliance was set to 50 °C, and after a pre-heating time of approximately one hour had elapsed, the temperature of the copper plate and the heat-radiating member specimen were measured every 15 seconds (three electrical heating appliances were prepared, and the temperature of the three copper plates and heat-radiating member specimens were measured at the same time).

[0063] The test results that were obtained under the above conditions are shown in the tables below. The very bottom section on the right side of each table shows the average temperature of the heat-radiating member specimen, the average temperature of the copper plate, and the average temperature difference, which was calculated by subtracting the average temperature of the heat-radiating member specimen from the average temperature of the copper plate.

[Table 9]

Test results for an acrylic volatile synthetic resin coating material

t	Acrylic coating	Copper plate temperature	Room temperature	t	Acrylic coating	Copper plate temperature	Room temperature
	45.2	49	26.2	6	45.7	49.8	26.4
	45.2	48.7	26.2		45.7	49.8	26.4
	45.1	48.8	26.2		45.6	49.8	26.4
	45	48.6	26.2		45.4	49.6	26.4
1	45	48.8	26.2	7	45.2	49.4	26.4
	44.9	49.1	26.3		45.1	49.3	26.4
	45	49.2	26.3		45.7	49.4	26.4
	45.1	49.5	26.3		45	49.3	26.4
2	45.1	49.6	26.3	8	44.9	49.4	26.4
	45.1	49.8	26.4		45	49.6	26.4
	45.2	50	26.4		45.1	49.8	26.3
	45.3	50.3	26.4		45.2	49.9	26.3
3	45.3	50.3	26.4	9	45.2	49.8	26.3
	45.3	50.4	26.4		45.3	49.7	26.3
	45.3	50.4	26.4		45.3	49.7	26.3
	45.4	50.6	26.4		45.4	49.9	26.3
4	45.4	50.5	26.4	10	45.4	50	26.3
	45.6	50.5	26.4				
	45.7	50.2	26.4				
	45.8	50.2	26.4				
5	45.8	50	26.4		45.32	49.71	**4.39**
	45.8	49.9	26.3				
	45.8	49.9	26.4				
	45.7	49.8	26.4				

[Table 10]

Test results for a water-based emulsion type coating material

t	Water-based coating material	Copper plate temperature	Room temperature
	44.9	48.6	26
	44.8	48.6	26
	44.8	48.6	26
	44.9	48.9	26
1	45	49.2	26
	45.1	49.3	26
	45.1	49.2	26.1
	45	49.4	26.1
2	45.1	49.5	26.1
	45.1	49.5	26.1
	45.1	49.2	26.4
	45.1	49.3	26.1
3	45.2	49.2	26.1
	45.2	49.2	26.1
	45.3	49.1	26.1
	45.4	49.1	26.1
4	45.4	49.1	26.1
	45.4	48.9	26.1
	45.2	48.8	26.1
	45.1	48.6	26.1
5	45	48.3	26.1
	45	48.3	26.1
	45	48.3	26.1
	44.9	48.3	26.1
6	44.9	48.1	26.1
	44.9	48.4	26.1
	44.8	48.5	26.1
	44.8	48.8	26.1
7	44.8	49	26.1
	44.9	49.2	26.5
	45	49.2	26.1
	45.1	49.3	26.1
8	45.1	49.7	26.1
	45.2	49.7	26.1
	45.2	49.7	26.1
	45.2	50	26.1
9	45.4	50	26.1
	45.5	49.8	26.1
	45.5	50	26.1
	45.6	50.1	26.1
10	45.7	50	26.1
	45.11	49.12	4.01

[Table 11]

Test results for a two-component epoxy type coating material

t	Epoxy	Copper plate temperature	Room temperature	t	Epoxy	Copper plate temperature	Room temperature
	45.5	50	26.3	6	44.8	48.9	26.3
	45.4	50	26.3		44.9	48.9	26.3
	45.5	50	26.3		44.9	49	26.3
	45.5	50.1	26.3		44.8	49	26.3
1	45.7	50.1	26.3	7	44.8	49	26.3
	45.7	50	26.3		45	49.1	26.3
	45.8	50	26.3		45.2	48.8	26.3
	45.8	50.3	26.4		45.1	49	26.3
2	46	50.3	26.3	8	45.1	49.2	26.3
	45.9	50.1	26.3		45.2	49.2	26.3
	45.9	50	26.3		44.9	49	26.3
	45.9	50.1	26.4		44.8	48.6	26.3
3	45.7	49.8	26.3	9	44.8	48.5	26.3
	45.6	49.4	26.3		44.8	48.7	26.3
	45.7	49.4	26.3		44.6	48.8	26.3
	45.8	49.3	26.3		44.7	48.8	26.4
4	45.6	49.3	26.3	10	44.6	48.1	26.4
	45.5	49.1	26.3				
	45.5	48.8	26.3				
	45.3	48.5	26.3				
5	45.3	48.5	26.3		45.28	49.26	**3.98**
	45	48.7	26.3				
	44.9	48.8	26.3				
	44.9	48.4	26.5				

[0064] From the above, it was found that an acrylic volatile synthetic resin coating material is preferred for use as a fixing agent.

[0065] In this way, from the results of the grain-diameter-selection test, coating-amount-selection test and fixing-agent-selection test it was found that a tourmaline layer, which is formed by mixing schorl tourmaline powder, having a grain diameter of 6 μm, with a fixing agent, which is made from acrylic volatile synthetic resin coating material, at a weight ratio of 1:1 to create a coating agent (coating-agent creation step), then applying that

coating agent to a base material until the density of the schorl tourmaline powder becomes 0.05 grams per cm^2, is most preferred.

(Embodiment 2)

[0066] Next, detailed applications of the heat-radiating member 1 in various devices will be explained. In this case, the heat-radiating member does not have to be formed into a thin plate shape as shown in embodiment 1, and can be formed by forming a tourmaline layer 12, as was described in embodiment 1, on a base material 11 that was formed into a desired shape (heat-radiating fin, etc.) and from a desired material (aluminum, etc.), or by mixing schorl tourmaline powder with the base material itself.

[0067] First, an example of using the heat-radiating member in the heat-exchange system of a refrigerator will be explained using Fig. 3.

[0068] As shown in Fig. 3, the heat-exchange system E of a refrigerator uses well-known construction and comprises: a compressor e1, a refrigerant tank e2, cooling compartment e3, heat-radiation-function unit e4, and piping e5 that connects these components together, so all of these components form heat-radiating members 1 on which a tourmaline layer 12 is formed on base materials 11 that are formed in the respective required shapes.

[0069] A refrigerator that has been constructed using heat-radiating members 1 in this way has improved heat-exchanged effectiveness due to the improved heat-radiation effect, so is extremely preferred.

[0070] Next, an example of construction in which heat-radiating members 1 are used in required locations in a computer F is explained with reference to Fig. 4.

[0071] On the inside of a normal computer F, between the case (frame) f1, chassis f2 and all hardware f3 is treated with metal plating or the like, or the metal material is exposed as is. However, in this state, internally generated heat is repeatedly reflected by all of these members, making it difficult for the heat to escape to the outside, so this state is near a so-called thermos state.

[0072] Therefore, by constructing each of the components like the case (frame) f1, chassis f2, hardware f3 such as a HDD, DVD or the like as heat-radiating members 1 having a tourmaline layer 12, it is possible to prevent the reflection of internal heat, and by consuming that internal heat, it is possible to lower the internal temperature of the computer F.

[0073] Here, heat-radiation effect was tested for two external hard disc drives (IO DATA; HAD-iE160) as the objects to be tested. One of the cases was kept as a normal HDD (untreated), and the other case was treated with a tourmaline layer. When forming this tourmaline layer, schorl tourmaline powder having a grain diameter of 6 μm was mixed with a fixing agent made from an acrylic volatile synthetic resin coating material at a weight ratio of 1:1 (coating agent creation step) to create a coating agent, then that coating agent was coated on top all of the surfaces of the case until the density of the schorl tourmaline was within the range 0.05 to 0.025g per cm^2, and in the test, the temperature was measured after specified amounts of time. The test results are shown in Table 12.

[Table 12]

Temperature Comparison of External HDDs

IO DATA [HAD-iE160]	Measurement time	Room temperature	Normal HDD	Treated HDD	Measurement time	Room temperature
40 minutes after the power is turned on, and after HDD was used continuously for 10 minutes	11:53:00	25.9	36	35.9	10:10:00	25.8
40 minutes after the power is turned on, and after HDD was used continuously for 20 minutes	12:03:00	25.9	37.5	37.3	10:20:00	25.7
40 minutes after the power is turned on, and after HDD was used continuously for 30 minutes	12:13:00	25.8	38.7	37.9	10:30:00	25.8
40 minutes after the power is turned on, and after HDD was used continuously for 40 minutes	12:23:00	25.9	39.5	38.2	10:40:00	25.7
40 minutes after the power is turned on, and after HDD was used continuously for 50 minutes	12:33:00	25.9	40.3	38.7	10:50:00	25.8
40 minutes after the power is turned on, and after HDD was used continuously for 60 minutes	12:43:00	25.8	40.4	39.4	11:00:00	25.8
40 minutes after the power is turned on, and after HDD was used continuously for 70 minutes	12:53:00	24.8	40.6	39.7	11:10:00	25.9
40 minutes after the power is turned on, and after HDD was used continuously for 80 minutes	13:03:00	25.2	40.8	40.1	11:20:00	25.9
40 minutes after the power is turned on, and after HDD was used continuously for 90 minutes	13:13:00	25.3	41.2	40.1	11:30:00	25.9
40 minutes after the power is turned on, and after HDD was used continuously for 100 minutes	13:23:00	25.7	41.3	40.1	11:40:00	25.9
40 minutes after the power is turned on, and after HDD was used continuously for 110 minutes	13:33:00	25.7	41.8	40.1	11:50:00	25.9
40 minutes after the power is turned on, and after HDD was used continuously for 120 minutes	13:43:00	25.7	41.8	40.1	11:50:00	25.9
40 minutes after the power is turned on, and after HDD was used continuously for 130 minutes	13:53:00	25.7	41.8	40.1	11:50:00	25.9
40 minutes after the power is turned on, and after HDD was used continuously for 140 minutes	14:03:00	25.7	41.8	40.1	11:50:00	25.9
40 minutes after the power is turned on, and after HDD was used continuously for 150 minutes	14:13:00	25.7	42.2	40.1	11:50:00	25.9
40 minutes after the power is turned on; and after HDD was used continuously for 160 minutes	14:23:00	25.7	42.1	40.1	12:00:00	25.9
Maximum temperature		25.8	42.1	40.1		25.9
Minimum temperature		24.6	31.4	31.5		25.6
Average temperature after 60 minutes	—	25.650	41.540	40.060	—	25.850
Remarks	Power was turned ON at 8:00				Power was turned ON at 9:00	

[0074] In this test the obtained measurement results showed that that the average temperature of the case of the normal HDD after 60 minutes was 41.540 °C, and the temperature of the case of the HDD treated with a tourmaline layer was 40.060 °C, thus it was possible to confirm a drop in the case temperature.

[0075] The computer F shown in Fig. 4 is a desktop computer, however, as shown in Fig. 5, the invention can be applied to a notebook computer G as well. A typical notebook computer case (frame) g1 is made from a metallic material or a non-metallic material such as polycarbonate. Therefore, by forming the case g1 such that schorl tourmaline powder is mixed in, it is possible to disperse and consume internal heat and thus prevent a rise in internal temperature of the notebook computer G.

[0076] Normally, the chassis and frame of all parts are treated with metallic plating, or metallic members are exposed as they are. In this kind of state, it is difficult for internally generated heat to escape to the outside.

[0077] In order to solve this problem, by constructing the chassis or the like using a heat-radiating member 1, then by promoting internal heat radiation and consuming that internal heat, it is possible to prevent an increase in temperature inside the machine.

[0078] For example, as shown in Fig. 6, the housing (frame) h1 of an electric motor H can be constructed using a heat-radiating member 1.

[0079] Also, it is possible to construct the support stand 3 on which an existing notebook computer N is placed using a heat-radiating member 1, and, as shown in Fig. 7, in this case, the heat-radiating member 1 can be a support stand 3 that is constructed such that it is wide enough that the notebook computer N can be placed on it, and bent into an L shape, as seen from the side, so that it is at a sufficient height for the notebook computer N to be placed at a desired angle.

[0080] By placing the notebook computer N on a support stand 3 that is constructed in this way, the heat that is transferred from the case (frame) of the notebook computer N is transferred to the support stand 3, and is efficiently radiated from this support stand 3. Therefore, it is possible to further improve the heat-radiation effect without doing anything to the existing notebook computer N.

[0081] Here, the heat-radiation effect was tested for the note computer itself, a support stand (copper plate only) that had no tourmaline layer, and the support stand 3 on which a tourmaline layer was formed (copper plate + tourmaline layer). The tourmaline layer was formed by mixing schorl tourmaline powder having a grain diameter of 6 μm with a fixing

agent made from an acrylic volatile synthetic resin coating material at a weight ratio of 1:1 (coating agent creation step) to create a coating agent, and applying this coating agent to all surfaces so that the density of schorl tourmaline became about 0.025 g per cm^2. Also, a temperature sensor was place in the center of the bottom surface of the notebook computer to measure the temperature. The test results are shown in Table 13.

[Table 13]

Temperature measured on the bottom surface of a notebook computer

	No support stand	Support stand (copper plate only)	Support stand (with tourmaline layer)
8 hours after the power was turned ON, and after using a DVD for 60 minutes	43. 2℃	42. 5℃	39. 4℃
Room temperature	25. 8℃	25. 8℃	25. 8℃
Remarks		The temperature was still rising	When changing from a state of no plate, to an angled tourmaline plate, the temperature rose temporarily to 40 ℃; however, it eventually became steady at 39.4 ℃

[0082] From these test results, it was found that by simply placing a notebook computer on a support stand 3 formed with a tourmaline layer, effective heat radiation became possible.

[0083] Therefore, it is possible to apply a heat-radiating member 1 to a new structure in this way to further improve the heat-radiation effect without doing anything to the existing object.

[0084] Furthermore, needless to say, in addition to the computer described above, the invention can be applied to all kinds of devices such as broadcast equipment, video equipment, communication equipment, routers, switches, amplifiers, and the like. Also, the invention can be freely applied to other single devices or parts such as the heat-emitting unit of a LCD panel, light-receiving unit of a solar battery, all kinds of transformers, electric motors, heat-radiating unit of a cooling device, coolant compressor, heat-radiating unit of an air-conditioner, automobile radiator, automobile parts, etc.

[0085] The embodiments described above are examples of the preferred embodiments of the invention, and the invention is not limited to these and can be changed within the scope of the invention.

[0086] For example, the tourmaline layer can be formed on both surfaces of the base material and not just the top surface or a surface that is in contact with the outside. Also, it can be formed inside the base material in a sandwich type construction. Moreover, the material of the base material is not particularly limited. Furthermore, the shape is not particularly limited to a thin plate shape or bar shape. Also, the tourmaline layer can be colored.

[Industrial Applicability]

[0087] With this invention, a coating agent, which is made by mixing schorl tourmaline having a grain diameter of 3 to 7 μm with a liquid-form fixing agent, is applied to the surface of a base material made from a metal such as copper, aluminum or the like having excellent thermal conductivity, and allowed to harden to form a heat-radiating member having a tourmaline layer, so it is possible to obtain a heat-radiating member that can be manufactured very inexpensively and easily, as well as obtain a heat-radiation effect that is much greater than that of a conventional heat-radiating member that is formed by using a black coating.

[0088] By applying the heat-radiating member of this invention to various objects such as machinery (including parts), appliances, electronic parts, and the like that must radiate heat, it is possible to improve efficiency, reduce the number of parts and simplify construction.

[0089] Particularly, by constructing the heat-exchange system of a cooling apparatus by using the heat-radiating member of this invention, it is possible to lower the temperature of the cooling apparatus and provide a very suitable cooling apparatus by improving the heat-radiation effect (improving heat exchange).